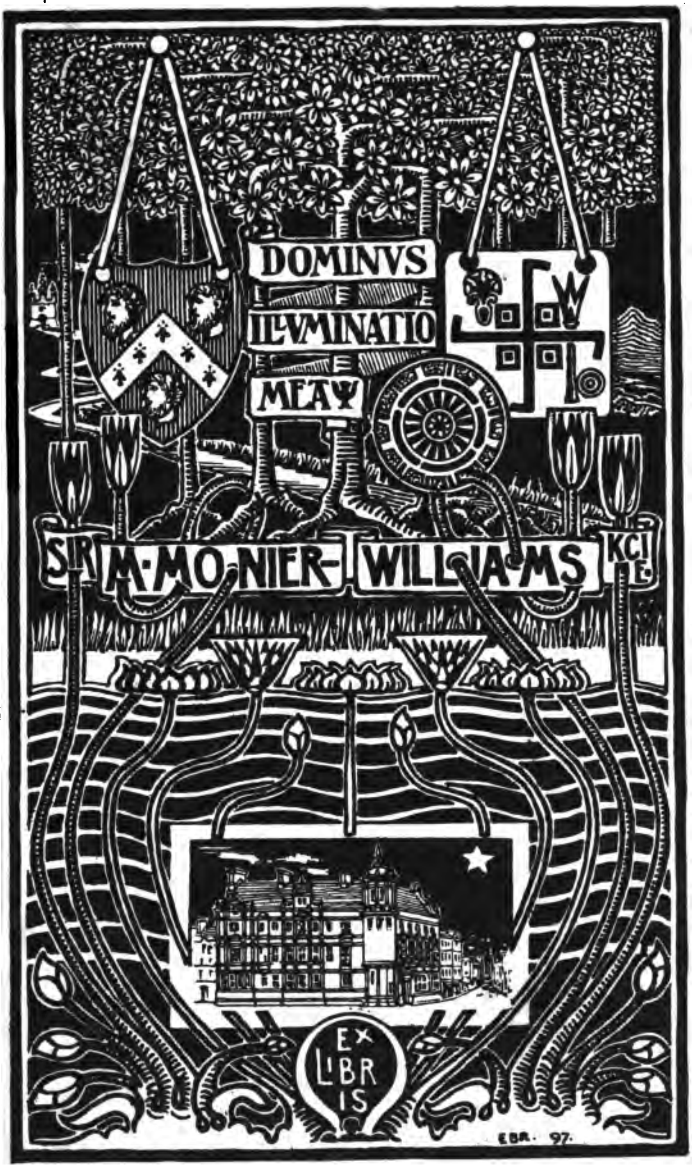
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THE MÁNMANDIRA OBSERVATORY,

BY

PANDIT BAFU DEVA SHASTRÍ,
HONORARY MEMBER OF THE ROYAL ASIATIC SOCIETY, LONDON
PROFESSOR OF MATHEMATICS AND ASTRONOMY, SANSKRIT COLLEGE, BENARES.

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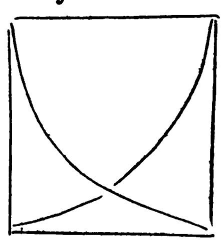
In the City of Benares, a celebrated building called MÁNAMANDIRA, is situated on the bank of the Ganges at a litte distance from the MAṆI-KARṆIKÁ Ghát, towards the S. W. This building and the Ghát below were erected by MÁNA-SINHA, the Rájá of Ambheri, in Rájputáná; and hence the building is so named. To the inheritance of MÁNA-SINHA, a great and powerful Rájá, JAYA SINHA, succeeded. About 150 years ago JAYA-SINHA constructed several instruments in the MÁNAMANDIRA for observiug the planets and stars. I will now explain these instruments, with their use, and their present state.

1.—BHITTIYANTRA (A Mural Quadrant). When you enter the MÁNAMANDIRA you will first find the BHITTIYANTRA. It is a wall built of bricks, lime, and stones in the plane of the meridian. Its height is 11 feet, length 9 feet and 1¼ inches, and breadth 1 foot and ⅛ inch. Its east side which is covered with plaster of pure lime is very smooth. At the top of this side near its two corners, two spikes of iron are fixed perpendicular to the plane of the wall. They are at a distance of 10 feet and 4½ inches from the ground and of 7 feet and 9½ inches from each other. With the points where the spikes are fixed, as centers, and a radius equal to the distance between the spikes, two quadrants are described intersecting each other as in the accompanying figure.



With the same points, as centers, out of each of the quadrants, three concentric arcs are described, and divided into equal parts in such a manner that one division in the upper arc is equal to six degrees, in the second one degree, and the in third six minutes.

When the sun comes on the meridian, the division of the arc at which the spike's shadow falls, will shew the Sun's altitude and zenith-distance at noon. In Benares, the Sun never comes to the north of the zenith, and therefore, to observe the Sun's altitude and zenith-distance,

only that quadrant will serve, which has its centre to the south. This quadrant will serve also for taking the meridianal altitude of the stars which pass over the meridian to the south of the Zenith; but the other quadrant, whose centre is to the north, will be useful to observe the meridianal altitude of those stars which come on the meridian to the north of the Zenith.

With this instrument, the Sun's greatest declination and the latitude of the place, can be determined thus.

By successive observations of the meridianal zenith-distances of the Sun, his greatest and least zenith-distances can be obtained. Then the half of the difference between the greatest and least zenith-distances of the Sun, will be the Sun's greatest declination. Subtract it from the greatest zenith-distance, or add it to the least zenith-distance of the Sun, the remainder or the sum will be the latitude of the place.

This mode of computing will serve, when the Sun never comes to the north of the zenith. With this instrument, JAYA-SINHA determined the greatest declination of the Sun to be 23°, 28′.

By means of the latitude of the place and the Sun's meridianal zenith-distance observed at any noon, the Sun's declination can be very easily ascertained as follows. Find the difference between the latitude and the Sun's meridianal zenith-distance. This difference will be the Sun's declination at that noon. If the degrees of the zenith-distance be less than those of the latitude, the declination thus found will be north, but if the degrees be greater, the declination will be south. By the declination thus found, and the Sun's greatest declination, the Sun's longitude can be easily found.

To the east of this wall, there was a smooth space close to it, which has now become somewhat rough. The breadth of this is equal to that of the wall, and its length is 10 feet and 3 inches. In each of its eastern corners there is a spike with a hole at the top, just to the east of the spikes of the wall respectively. Out of them the southern spike has been taken but the northern is still in the same state. It does not strike me as yet for what purpose the spikes are so fastened.

Near this space, there is a circle built of lime with a diameter equal to 2 feet and 8 inches. There is another circle of stone whose diameter is 3 feet and 5 inches, and a square built of stone, the side of which is equal to 2 feet and 2 inches. These two circles, and the square, might have been made to ascertain the shadow of the gnomon cast by the Sun, and the degrees of azimuth. But all the marks made over them are now obliterated.

2.—Somewhat to the east, to the north of this instrument, there is a large instrument called YANTRA-SAMRÁṬ (the prince of instruments) which has a wall of bricks and lime just in the plane of the meridian, the breadth of which is 4 feet and 6 inches and its length is 36 feet. The upper part of this wall, paved with stones, slopes and points to the north pole. Therefore the southern end of this wall is 6 feet and 4¼ inches high, and the northern is 23 feet and 3½ inches. This wall is called gnomon, and has stairs of stones in the middle of it to ascend to its top. On each side of the gnomon, *i. e.*, eastern and western, there is an arc of stones somewhat greater than a quadrant of a circle, the breadth of which is 5 feet and 11 inches, and its thickness is 7½ inches. Both sides of each of the arcs are marked with GHAṬÍs of six degrees each, each of which is divided into six equal parts. The breadth of this sixth part is 2 inches. The centres of both circular edges of each of the arcs, are in the upper edge of the gnomon. To each of these centres a small ring of iron is applied. The radius of the lower edge of each of the arcs is 9 feet 8¼ inches.

In this instrument, the part of the arc on which the shadow of the gnomon falls denotes the NATA-GHAṬÍs or the time from noon. If the time at which the shadow of the gnomon is observed be before noon, the noon will take place when those ghaṭís are over, and if the time be after noon, it has taken place before by them. To observe the shadow of the gnomon closely, stairs of stones are constructed on both sides of each of the arcs. But the upper part of each of the arcs being deflected about one inch below, the hour pointed out by the gnomon's shadow will not be known exactly.

As the shadow of the gnomon cast by the Moon is not so clearly seen as that by the Sun, and the shadow by the small planets and stars is not at all reflected, the way, therefore, to find the NATA-GHAṬÍs (or the distance in time from the meridian) of the Moon, planets and stars, is as follows:—

Place an iron wire or a straight iron tube at the instrument in such a manner that its one extremity be at the edge of the arc, and the other at the gnomon; then observe through that end of the tube or wire which is at the edge of the arc, the planet or star which is to be seen, moving the tube in such a manner that the planet or star may be seen just within the tube, and thus the mark of the lower edge of the arc, cut by the tube, will point out the distance of the planet or star, in time, from the meridian. The space of the edge of the gnomon intercepted between the centre of the arc to the tube is the tangent of

declination of the planet or star. Thus the distance from the meridian and the declination of the planet, star and the Sun, will be known through this instrument. The right ascension of a star is also found through this instrument in this way.

Find the Sun's distance, in time, from the meridian when he is about to set, and from this moment reckon the time through a timepiece, till the star, whose right ascension is to be found, is clearly seen. Add this time, so reckoned, to the Sun's distance from the meridian, and the time thus found, will be the Sun's distance from the meridian at that moment. Moreover, add the right ascension of the Sun, (determined at the moment,) to the result thus found, and you will get the right ascension of the culminating point of the ecliptic. Now find the star's distance from the meridian through the instrument, and add it to or subtract it from the right ascension of the culminating point of the ecliptic, according as the star be at the eastern or western hemisphere, and the result thus found will be the right ascension of the star.

A double Mural Quadrant has been constructed here, also on the eastern side of the gnomon of this instrument, the construction of which is just like that of the former; the difference lies only in this that the distance between the two spikes in the latter is 10 feet and 4½ inches.

3.—To the east of this instrument there is an instrument called the Equinoctial circle, made of stone, and placed in the plane of the Equinoctial, at the northern side of which a circle is described with a diameter, equal to 4 feet and 7¼ inches. In this circle two diameters are drawn, one upright and the other horizontal, at right angles to each other, and thereby the circle is divided into four equal parts, each of which is subdivided into 90 equal parts. In the centre of this circle, a spike of iron is inserted. This spike points to the north pole and denotes through its shadow the distance of the Sun or the star (from the meridian) when it is in the northern hemisphere; and in order to ascertain the distance of the Sun or any star (from the meridian), when it is in the southern hemisphere, a small circle is described with a diameter equal to 2 feet and 3¾ inches, at the southern side of the instrument, Having also divided this circle into four parts, by drawing two diameters just in the same manner, as are drawn in the former one, each quadrant is divided into 90 equal parts.

4.—To the east of the Equinoctial circle, there is another instrument of small dimensions, just of the same form as YANTRASAMRÁṬ. The length of the gnomon of this instrument is 10 feet aud 1 inch, and its breadth is 1 feet and 3 inches: the height of the southern extremity

of the gnomon is 3 feet and 6¼ inches, and that of the northern is 8 feet and 3 inches. The breadth of each of the arcs is 1 foot and 9¼ inches, its thickness 3¾ inches, and the diameter of the lower edge of the arc is equal to 3 feet and 5¾ inches.

5.—Near this there is an instrument called CHAKRAYANTRA, placed between two walls. This consists of a moveable circle of iron, one inch thick, faced with a plate of brass $\frac{3}{10}$ of one inch thick, turning upon an axis, which points to the north pole, and which is fastened to the two walls. The breadth of the rim of this circle is 2 feet, and its circumference is divided into 360 equal parts, the breadth of each of the subdivisions being $\frac{3}{10}$ of one inch. This circle has a peg at its centre, to which an index of brass is attached. The breadth of this index is 2 inches, its end is of this form, and it has in its middle a line passing through the centre of the circle.

In order to find the declination of a planet or star with this instrument, move the circle and the index in such a manner that the planet or star may come to the middle line of the index, and then the degrees on the circle, intercepted between the diameter which is at right angles at the axis, and the index, are the degrees of declination of the planet or star.

It appears that this instrument might have been invested with other circles also, such as colures, &c., which serve to ascertain the distance from the meridian, &c., of any planet or star; but then all are now spoilt, and the index also is now bent, and consequently the declination cannot now be found with this instrument in the way above mentioned.

6.—To the east of this, a large instrument called DIGANŚA YANTRA is situated. In the middle of it there is a pillar of cylindrical form, whose height is 4 feet and 2 inches, and the diameter of which is 3 feet and 7½ inches. To the centre of this pillar, a spike of iron with a hole at its top is fixed. The pillar is surrounded with a circular wall, which is from it at a distance equal to 7 feet and 3¼ inches, whose height is just equal to that of the pillar, and its breadth is 1 foot and 6 inches. Around this wall, at a distance of 3 feet and 2½ inches, there is a large circular wall, the height of which is twice that of the first wall, and its breadth is 2 feet and ¾ of one inch. The upper parts of both of these walls are marked with the points of the compass and 360 degrees, and on the upper part of the outer wall four spikes are planted in the four cardinal points. This large instrument is only constructed to find the degrees of azimuth of a planet or star, which are thus found.

Stretch two threads from the four spikes which are fixed in the upper part of the outer wall, that is, one from the eastern spike to the western, and the other from the northern spike to the southern, which will intersect each other just above the centre of the pillar. Take another thread, fasten one end of it firmly to the centre of the pillar, and convey the other end to the top of the outer wall. Then apply your eye to the circumference of the middle wall, and observe the planet or star whose azimuth is to be ascertained, moving your eye and the thread stretched from the centre of the pillar to the top of the outer wall, in such a way, that the planet or star and the point of intersection of the two former threads may come to the thread so moved, and thus you will find the degrees of azimuth of the planet or star between the place of the upper part of the outer wall, where the thread so moved is then situated, and the north or south point of that wall.

7.—To the south of this instrument there is another Equinoctial circle, which is constructed in the same way as the former ; its diameter is 6 feet and 3 inches ; the central spike is lost, and the marks and divisions upon it are all totally effaced.

The division and the marks of almost all the instruments also are blotted out, and the instruments also are somewhere broken and deflected.

Thus I have given an account of all the instruments, and briefly shown their uses also.